Project Management Plan

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Fermilab
CD-2/3a Director's Review of NOvA
June 4-6, 2007

Project Management Plan

- Project Execution Plan (PEP) describes how the Project interacts with the DOE at a high level.
- Project Management Plan (PMP) picks up from the PEP and describes how the Project interacts with the Lab, Divisions and Sections.
- Includes management structure, roles & responsibilities from Lab management on down, WBS, change control procedures, etc…

Project Management Plan

- Includes Summaries of:
  - Risk management Plan
  - Project Controls System
  - Quality Assurance Plan
  - Configuration Management Plan
  - Acquisition Strategy
- Points at separate documents that describe these plans in greater detail.

New since CD-1

- Added ANU
  - Added WBS 1.0 and 2.0
  - Added roles and responsibilities for AD and TD.
- Description of Cooperative Agreement including interfaces with NOvA Project & DOE.
- Section on engineering design review.
- Condensed chapter on Quality Assurance Plan and made a separate document

Org Chart

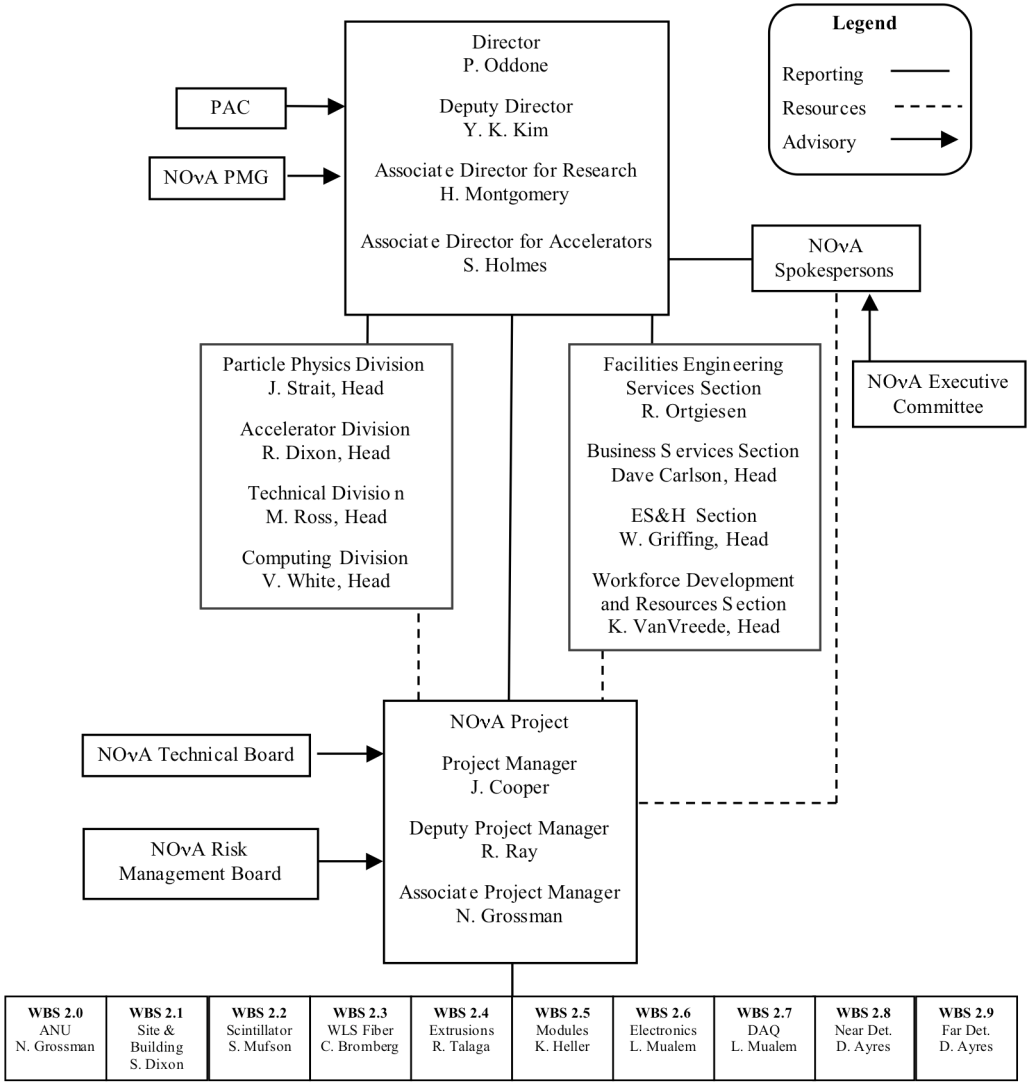

Figure 3.1 Organization chart for the NOvA construction project through WBS Level 2

Cooperative Agreement

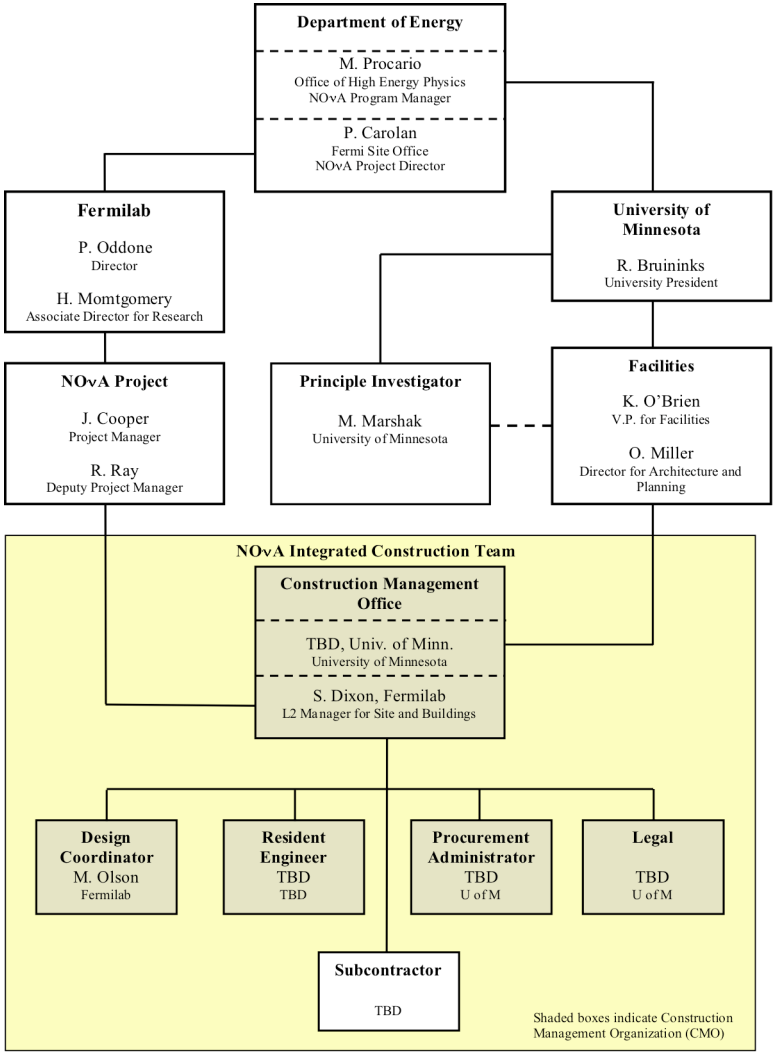

Figure 4.1 Organization chart for the NOvA Integrated Construction Team.

Change Control

Table 6.1 Fermilab technical, schedule, and cost baseline control levels.

	Fermilab Associate Director (Level 3)	**NOvA Project Manager (Level 4)**	**Subproject Manager (Level 5)**
Technical	Major technical changes that are significant departures from the technical baseline. Changes that affect ES&H requirements or impact PoT projections by more than 10%. Out-of-scope changes to upgrade physics capabilities.	Related technical changes to multiple subprojects that do not diminish performance.	Minor technical changes to a single subproject that does not diminish performance.
Schedule	Any change that results in the delay of a Level 3 Director's milestone.	Any change that results in the delay of a Level 4 milestone by more than one month.	Any change that results in the delay of a Level 5 milestone by more than one month
Cost	Increase in the cost of a single item by more than $200k. Increase in the Project base cost exceeding $500k during the previous 12 months.	Increase in the cost of a single item by more than $50k.	Increase in the cost of a single item by more than $10k.

Preliminary Project Management Plan for the NOνA Project

Fermilab

January 22, 2007

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Submitted, Approved, and Accepted By:

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NOνA Project Management Plan
Change Log

Revision No.	Pages Affected	Effective Date
Revision 0	Entire document	July 25, 2005
Revision 1	Add cost tables and milestones after presentation at CD1 Director's Review.	March 8, 2006
Revision 2	Update tables and costs for 25 kt detector	March 31, 2006
Revision 3	Add in Proton Plan 2	January, 2007
Revision 4	Tweaked Table 6.2 to agree with PEP. (RR)	April 16, 2007
Revision 5	Added section on engineering design review	May 2, 2007
Revision 6	Added table 5.1 (RR)	May 14, 2007

Project Management Plan
for the
NOνA Project

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1 INTRODUCTION

The NOνA Project Management Plan describes the physics, technical, cost, and schedule objectives for the NOνA Project, which provides for accelerator and beamline upgrades, the Far Detector Building, supporting experimental facilities and detectors for the NOνA experiment. It serves as a supplement to the "DOE Project Execution Plan for the NOνA Project" (the PEP), and provides further details specific to the NOνA Project.

1.1 Historical Background

The High Energy Physics (HEP) program of the Department of Energy (DOE) Office of Science conducts basic research into the nature and interactions of the fundamental constituents of matter. A major component of the US HEP program is the Fermi National Accelerator Laboratory (Fermilab). The NOνA experiment will use the NuMI facility at Fermilab to study neutrino oscillations to determine if muon-type neutrinos oscillate to electron-type neutrinos. The significance of the search for these oscillations is that, if they exist at a measurable level, we will ultimately be able to determine the mass ordering of the neutrino masses and search for CP violation in neutrino oscillations. There is good reason to believe that the very small neutrino masses are related to physics at an extremely high-energy scale that cannot be studied directly with accelerator beams. There is also theoretical speculation that CP violation by neutrinos could be one of the key ingredients necessary to understand why the Universe is composed solely of matter, rather than equal amounts of matter and antimatter.

The NOνA experiment, E929, was proposed in March of 2005, after several stages of pre-proposal activity and evaluation, and was approved by the Director in April of 2005.

1.2 The NOνA Project

The purpose of the NOνA Project is to design, construct, and install the NOνA detectors and to modify and upgrade the accelerator and NuMI beamline in order to achieve the physics goals set out in the NOνA Proposal. To meet the scientific and technical objectives for the NOνA experiment, the following goals must be achieved:

(a) The Fermilab Recycler will be converted from an anti-proton to a proton storage ring, the Main Injector cycle time will be reduced, and the NuMI neutrino line will be upgraded to handle a substantial increase in beam power and modified to operate in the medium energy neutrino configuration.
(b) The NOνA Project requires construction of a detector enclosure in Northern Minnesota to house the NOνA far detector. The enclosure will also include adequate space and infrastructure to facilitate construction and operation of the far detector. The enclosure should provide shielding against the photon component of cosmic rays. A Cooperative Agreement with the University of Minnesota is in place to construct and operate the detector hall for the NOνA Far Detector in Ash River, Minnesota.
(c) Design and construction of the far detector constructed from plastic PVC extrusions filled with liquid scintillator and designed to identify electron tracks from electron neutrinos that interact in the detector;

(d) Design and construction of a near detector to sit in the existing NuMI access tunnel used to measure backgrounds to the electron neutrino measurements in the far detector.

The goal of the complete project is to allow the experimenters, Fermilab, and DOE to meet the scientific objectives described in section 2.1. The timeframe for the Project is to begin construction in FY 2008 and complete the project in FY 2013. Operation of the full detector will begin in FY2013 but operation with a large portion of the detector can begin a year earlier.

1.3 Overview of this Document

This document describes the NOνA Project, the project objectives, organization, management, and review mechanisms. The document supplements the PEP by providing additional details specific to the management of the NOνA Project. Section 2 describes the mission justification, including scientific, technical, cost, and schedule objectives. Section 3 describes the Management, Organization, and responsibilities of the various participants. The following sections describe the detailed project objectives, along with a more detailed description of the project, followed by the work plan that will allow us to realize the Project, as well as the resources needed to construct the project. They address the Work Breakdown Structure (Section 4), Technical, cost, and schedule baselines (Section 5), change control thresholds (Section 6), risk management techniques (Section 7), the Project Controls System (Section 8), the Acquisition Strategy (Section 9), technical considerations (Section 10), Quality Assurance (Section 11), Value Engineering (Section 12), Configuration Management (Section 13) and the principles of the Safety Management System (Section 14). These are the procedures that will be implemented to assure an on-time and on-budget completion of the project.

1.4 Revision Control

This plan will be reviewed and revised, as required, to reflect new project developments and other agreements among participants. As revisions are issued, the DOE and NOνA signatories and the Fermilab Director and his/her designees will sign them. Signatures of other Fermilab officials will be at the discretion of the Fermilab Director. Once signed, the revision will supersede in its entirety previous editions. An entry will be made in the revision log to document the change. A detailed explanation and justification of the change will be placed in the NOνA Document System and announced to all stakeholders.

2 JUSTIFICATION OF MISSION

This section describes the scientific, technical, cost, and schedule objectives that define and justify the mission and goals of the project.

2.1 Scientific Objectives

The purpose of the project is to upgrade the beam power to the NuMI beam line, to construct the NOνA near and far detectors as well as the far detector hall and to install the detectors in a state ready to take data. The NuMI beamline will also be modified to run in the medium energy neutrino beam configuration. The far detector is constructed from PVC extrusions filled with liquid scintillator. Each of the extrusion cells contains a Wavelength Shifting (WLS) fiber to collect the scintillation light and

route it to an Avalanche Photo Diode (APD) optical detector. The technology for the near detector is identical to the far detector but implemented on a much smaller scale. The NOνA detectors will permit the experimenters to search for the oscillation of ν_μ to ν_e neutrinos. Once this oscillation is discovered it can be exploited to determine the mass ordering of neutrinos and to search for CP violation in neutrinos. The NOνA far detector, sited 810 km from Fermilab, has the longest baseline of any experiment proposed in the near future. A long baseline is necessary to determine the mass ordering and NOνA is uniquely positioned to make this determination.

2.2 Technical Objectives

The sensitivity of NOνA depends on the product of the proton beam power and the mass of the far detector. One of the goals of the NOνA Project is to increase the power of the NuMI beam to approximately 700 kW. A further upgrade beyond 1 MW is also expected but is not part of the current Project. Based on the number of protons expected on the NuMI target in a 6-year run, the mass of the NOνA detector has been set at 18 kt. If contingency can be saved along the way, additional mass can be added to the detector up to a maximum of 20 kt. This combination of beam power and detector mass makes NOνA the most sensitive proposed experiment for all of the scientific objectives listed previously.

The NOνA detector must be capable of observing ν_μ to ν_e oscillations by observing the interaction of the ν_e in the active detector and identifying the associated electron. Electrons appear in the detector as "fuzzy" tracks due to the way the electromagnetic shower evolves in the low Z material from which the detector is constructed. The detector must further be able to distinguish electron tracks from muons and π^0's that appear as background. An additional background results from electron neutrinos that are produced from the decays of pions and kaons near the NuMI target rather than from ν_μ to ν_e oscillations that take place over a long baseline. The NOνA near detector will be used to measure the off-axis ν_e content of the beam near the NuMI target and extrapolate that background to the far detector.

To meet the scientific and technical objectives for the NOνA experiment, the following goals must be achieved:

- The Fermilab accelerator complex must be upgraded:
    - The Recycler must be converted from an anti-proton to a proton storage ring for slip stacking with proton injection and extraction lines.
    - The Main Injector cycle time must be reduced.
    - The NuMI neutrino line must be upgraded to handle a substantial increase in beam power and modified to the medium energy neutrino beam configuration.
- The NOνA far detector hall must be constructed at an appropriate site in Northern Minnesota.
- The NOνA Far Detector must be constructed:
    - Plastic PVC extrusions must be manufactured to the appropriate size and shape. The inner walls of the extrusion cells must be highly reflective to maximize light collection. The extrusions will be sealed at both ends forming leak-tight containers that will hold liquid scintillator and wavelength shifting (WLS) fiber.

- The PVC extrusions must be glued together in alternating layers of vertical and horizontal extrusions into a strong, self-supporting honeycomb structure.
- The light produced by the liquid scintillator and collected by the WLS fiber is directed onto a pixilated Avalanche Photo Diode (APD) optical detector. The output from the APD must be amplified, digitized and zero-suppressed by the front-end electronics.
- A data acquisition system must accumulate the data from the front-end electronics and log the appropriate data to permanent storage.

2.3 Cost Objectives

The project cost is shown in Table B7 in actual year dollars. The funding plan for the Project is summarized in Table 9 of Appendix B. In addition to support from the DOE, funding is being sought through NOνA collaborators both in the United States and abroad.

2.4 Schedule Objectives

The primary schedule objectives for the project are summarized in Appendix B Tables 2, 3, 4 and 5. The schedule is consistent with the DOE schedule in the PEP.

2.5 Project Description

The detailed NOνA Project description is provided in the NOνA Technical Design Report. In the following 4 subsections, we describe the main elements of the project. Additional material appears in the description of the Work Breakdown.

NOνA Far Detector

The NOνA far detector is optimized for detecting low-energy (~2 GeV) electron showers while rejecting background events. High signal efficiency and good background rejection require frequent sampling in low-Z materials.

The far detector is a tracking calorimeter that reconstructs neutrino interactions in 3-dimensions. It is constructed from alternating vertical and horizontal planes of rigid PVC extrusion modules that are subdivided into 32 cells and filled with liquid scintillator. One plane of the detector is constructed from 12 extrusion modules. Each extrusion module is sealed with a closure block at one end and a manifold for fiber routing on the other end. A looped Wavelength Shifting (WLS) fiber is inserted into each liquid scintillator cell. Both ends of the looped fiber terminate on the same pixel of a 32-pixel Avalanche Photo Diode (APD) chip. The APD is followed by front-end electronics that amplify, multiplex, digitize and zero suppresses signals before passing them on to the data acquisition system.

The performance of the NOνA far detector will be determined by the amount of light collected from the detector compared to the amount of noise produced by the electronics. The amount of light collected from the detector depends on the amount of light produced by the liquid scintillator, the reflectivity of the inner surface of the PVC extrusions, the amount of light collected by the WLS fibers, the attenuation of light in the fibers, the quality of the optical fiber connection to the APD and the quantum efficiency

of the APD. Thermal noise in the APD and noise from the front-end amplifier are the primary sources of electronics noise. The APD is cooled with a thermo-electric cooler to -15° C to reduce thermal noise and the front-end electronics is specifically designed for low noise performance.

NOνA Near Detector

The NOνA near detector will operate on the Fermilab site at a distance of about 1 km from the NuMI target in the existing NuMI access tunnel. The purpose of the near detector is to measure backgrounds to ν_e identification that will appear in the far detector. The near detector contains a fully active section that is nearly identical to the far detector in its construction and a downstream muon catcher constructed from alternating planes of PVC modules filled with liquid scintillator and steel. The fully active part of the near detector has a total mass of about 220 metric tons. The near detector modules and the pieces that comprise the muon catcher are sized to fit down the MINOS access shaft and inside the NuMI access tunnel.

The neutrino interaction rate in the near detector is significantly larger than in the far detector, resulting in multiple interactions in the fiducial volume within the same 10 μs spill approximately 10% of the time. The near and far detectors use the same front-end electronics, but to facilitate identification of multiple interactions the near detector front-end electronics run at a higher sampling rate.

Far Detector Hall

The NOνA far detector requires a detector enclosure that is large enough to contain the far detector and to provide adequate space for detector assembly. The enclosure will sit in an excavation surrounded by solid granite and will be covered by an overburden sufficient to eliminate backgrounds from the electromagnetic component of cosmic rays. The enclosure has been designed to provide secondary containment for the full volume of liquid scintillator distributed through the ~14,000 modules that make up the far detector. Secondary containment is accomplished by coating the below-grade concrete walls with epoxy paint. The granite bedrock surrounding the buried building provides additional isolation from groundwater. The detector hall includes a truck staging area at grade level for the hundreds of truckloads of liquid scintillator that must be delivered to the site. Storage tanks and a piping system for the liquid scintillator are also included. The far detector hall must be completed before assembly of the far detector can commence and is on the project's critical path.

The DOE has received an unsolicited proposal from the University of Minnesota to conduct research on neutrino oscillations as part of the NOνA collaboration. As part of the research program the University proposes to construct the far detector enclosure on university owned land, to operate the building, to be responsible for security and ES&H, and to participate in the calibration, data-taking, maintenance of the NOνA detector and the subsequent data analysis.

Accelerator and NuMI Upgrades

The NuMI upgrade focuses on the steps necessary to increase the beam power in the Main Injector by making use of the Recycler ring (currently an anti-proton storage ring) as a proton pre-injector to the Main Injector, allowing the injection and the slipping portion of the slip-stacking process to be moved from the Main Injector to the Recycler. This pre-injection removes the proton injection time from the Main Injector cycle time and thereby enables the Main Injector to cycle as fast as allowed by magnets, power supplies and the RF system. Both modifications to the proton source and upgrades in the NuMI neutrino line to handle the higher beam power are required. The NOνA experiment requires a medium

energy neutrino beam and thus modifications to the NuMI Target Hall to provide this beam are necessary.

Project Management

This project is managed according to the procedures, roles and responsibilities as defined in this document. The laboratory appoints the Project Manager and concurs with the Project Manager's appointment of the Deputy and Associate Project Manager. The Project Manager appoints Level-2 managers in consultation with the collaboration spokespersons. The Project Manager runs the Project Office that contains the administrative and technical personnel required to support him/her in managing the project. Formal procedures, based on an Earned Value Management System, have been established to ensure that schedules are being met and costs kept under control. Change control procedures are in place.

3 MANAGEMENT, ORGANIZATION, AND RESPONSIBILITIES

3.1 Overview

The Project is funded by the DOE and managed through Fermilab. It is carried out in collaboration with universities and laboratories in the US and other countries. Its goal is to construct the NOνA detector and to upgrade the NuMI beam power to do world-class neutrino oscillation physics. The Project is to be managed to a predetermined scope, cost and schedule. The responsibilities for managing the project are shown in the organization chart, Fig. 3.1, and are described in the following sections of this chapter.

3.2 Department of Energy

The Department has established the need for the NOνA Project by considering and responding to advice from its advisory panel, HEPAP, HEPAP's prioritization P5 sub panel, NuSAG and the Fermilab Physics Advisory Committee. The Project was given CD-0 approval in November of 2005. The Department of Energy provides the funding for the Project. These funds are provided through the annual Fermilab financial plan by contract modification. The Office of High Energy Physics provides annual program guidance to the laboratory as well as annual guidance on the funding profile for the project. The Department exercises oversight of the Project by:

- Conducting periodic reviews of the project;
- Participating in regularly scheduled Project Management Group (PMG) meetings;
- Overseeing operations and fabrication activities;
- Monitoring project progress via monthly reports; and
- Monitoring milestones and performance measures.

The definition of the project, control of its scope, proposals for allocation of project contingency within bounds established in the PEP, oversight and interaction with the collaborating institutions and agencies are the responsibility of the NOνA Project Manager. The Project Manager also has the responsibility and authority for managing the project to deliver the approved scope within the total project cost estimate and on schedule. The management structure of the NOνA Project for the DOE is described in detail in the PEP.

The following sections relate to management roles of Fermilab management and the relation of the NOνA Collaboration to the project. The DOE oversight of the project is described in the NOνA PEP.

The portion of the Organization Chart for the NOνA Project at Fermilab is shown in Figure 3.1. Figure 4.1 of the Project Execution Plan (PEP) shows the DOE management structure that connects to this.

3.3 Fermilab Director

The Fermilab Director is responsible to the Fermi Research Alliance and the Department of Energy for the successful completion of the NOνA Project and only he/she is authorized to commit funds appropriated for Laboratory use. The Fermilab Director appoints the Fermilab NOνA Project Manager. The Director approves or concurs with the contents of the Technical Design Report (TDR), the Project Management Plan (PMP), the cost estimate, the schedule, the financial plan, and changes in scope for the Project. The Fermilab Director is ultimately responsible for ensuring that the project is carried out safely and with respect for the environment.

3.4 Fermilab Associate Director for Research

The Director has delegated certain responsibilities and authorities to the Fermilab Associate Director for Research. The Associate Director for Research holds primary responsibility for Fermilab's management oversight of the Project. He/she is assisted in this responsibility by the Associate Director for Accelerators (see 3.5). The Associate Director for Research advises the Director on the approval of the TDR, PMP, cost estimate, schedule, and financial plan and concurs with these approvals. The Associate Director for Research meets, as necessary, with the NOνA project management to help allocate resources from the organizations reporting to that office. He/she is responsible for providing a funding profile consistent with Laboratory funding after consultation and guidance from the DOE Program Office. The Associate Director for Research approves or concurs as appropriate with proposals for changes in the cost, schedule, scope or technical baseline of the project.

Oversight of the Project will be implemented in part through reviews including the Project Management Group and/or Director's Reviews. The Associate Director for Research chairs the Project Management Group and charges Director's Review panels. Along with routine interactions with project management, these reviews will identify actions and initiatives to be undertaken to achieve the goals of the Project including allocation of financial and human resources.

To implement the work plan for the Project, NOνA Memoranda of Understanding are executed with collaborating institutions. The Associate Director for Research, with the concurrence of the Director, approves all NOνA Institutional Memoranda of Understanding (MoU) related to the Project.

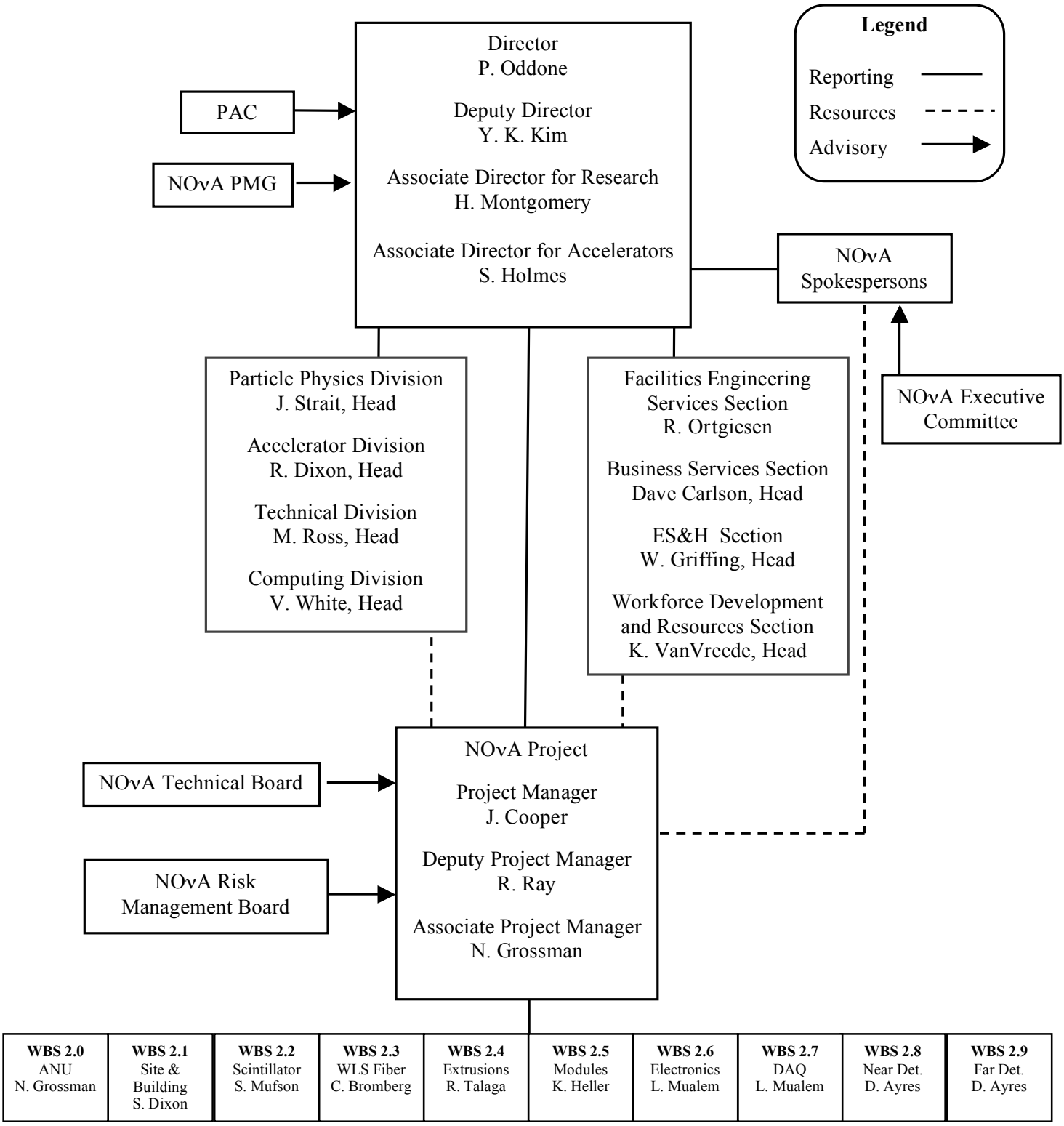

Figure 3.1 Organization chart for the NOνA construction project through WBS Level 2

3.5 Fermilab Associate Director for Accelerators

The Director has delegated certain responsibilities and authorities to the Fermilab Associate Director for Accelerators. The Associate Director for Accelerators assists the Associate Director for Research in providing Fermilab management oversight of the Project. The Associate Director for Accelerator holds primary responsibility for oversight of the construction and modification of accelerator facilities within the NOνA project. He/she will advise the Associate Director for Research on the approval of the TDR, PMP, cost estimate, schedule, and financial plan and concurs with these approvals. He/she serves as deputy chair of the Project Management Group and concurs as appropriate with proposals for changes in the cost, schedule, scope or technical baseline of the project.

3.6 Fermilab Particle Physics Division Head

The Fermilab Director and Associate Director for Research have delegated certain responsibilities and authorities to the Fermilab Particle Physics Division (PPD) Head. In particular, the Director has designated PPD as the host division for the NOνA Project and as such it provides the resources and home for the NOνA Project management. In addition to the host role, the PPD Head provides oversight for PPD financial resources, human resources, technical resources, space resources, and Environmental, Safety, and Health (ES&H) monitoring for the Project.

The PPD Head or a designee acceptable to the Laboratory Associate Director for Research is a member of the Project Management Group. The PPD Head advises the Associate Director for Research on approval of the sections of the NOνA Memoranda of Understanding that are relevant to PPD resources and funds. The PPD Head advises the Director and Associate Director for Research on approval of the PMP and the Cost/Schedule Plan (CSP) and concurs with these approvals.

On guidance from the Director, the PPD Head allocates yearly budgets to the Project. These project funds are then administered by the Project Manager, according to the responsibilities described below, within the context of PPD procedures and policies and with the support of the PPD budget office.

The PPD is the primary source of Fermilab personnel and technical resources for the Detector part of the project, as well as the project management activity. The PPD Head and his/her designees may make long-term assignments of PPD manpower directly to the project in consultation with the Project Manager and in accordance with the CSP. The Project Manager then deploys these people to achieve the project goals, reporting changes in assignments to the PPD Head. The PPD Head maintains line management responsibility for these PPD employees.

The PPD also provides support to the NOνA project through its systems and support departments. This is done in accordance with the CSP via specific work plans or NOνA Memoranda of Understanding. The PPD Head maintains direct line management responsibility for such PPD resources.

The PPD provides the personnel to staff the NOνA Project Office. The PPD also provides support to the project through PPD technical resource groups. This is done in accordance with the CSP via specific

work plans or NOνA Memoranda of Understanding. The PPD Head maintains direct line management responsibility for such PPD resources.

Since the PPD is the primary source for providing the Fermilab labor needed to achieve the project schedule goals for the detector, labor shortfalls must be reported in a timely fashion. The PPD head or designee will advise the Project Manager and Laboratory Associate Director for Research on the availability and sufficiency of labor resources to meet the project plan as indicated in the CSP. In the event of any mismatch in the availability of labor resources and the requirements, the Project Manager will conduct a schedule impact study and consider possible workarounds and propose a schedule variance in the event of a schedule impact to the Laboratory Associate Director for Research as required by the project controls.

3.7 Fermilab Accelerator Division Head

The Head of the Fermilab Accelerator Division (AD) is responsible for upgrades to, and operations of, the Fermilab accelerator complex including enhancements implemented as part of the NOνA Project. The AD Head reports to the Fermilab Director through the Associate Director for Accelerators and utilizes the NOνA Associate Project Manager (see Section 3.16) as his/her principal point of contract with the NOνA Project. The AD Head or a designee acceptable to the Laboratory Associate Director for Accelerators is a member of the Project Management Group. The AD Head advises the Associate Director for Research on approval of the sections of the NOνA Memoranda of Understanding that are relevant to AD resources and funds. The AD Head advises the Director and Associate Director for Accelerators on approval of the PMP and the Cost/Schedule Plan (CSP) and concurs with these approvals.

The AD Head and his/her designees may make long-term assignments of AD manpower directly to the project in consultation with the Project Manager, the Associate Project Manager, and in accordance with the CSP. The Associate Project Manager then deploys these people to achieve the project goals, reporting changes in assignments to the AD Head. The AD Head maintains line management responsibility for these AD employees.

The AD also provides support to the NOνA project through its systems and support departments. This is done in accordance with the CSP via specific work plans or NOνA Memoranda of Understanding. The AD Head maintains direct line management responsibility for such AD resources.

Since the AD is a significant source for providing the Fermilab labor needed to achieve the project schedule goals, labor shortfalls must be reported in a timely fashion. The AD head or designee will advise the Project Manager, Associate Project Manager, and Laboratory Associate Director for Accelerators on the availability and sufficiency of labor resources to meet the project plan as indicated in the CSP.

3.8 Fermilab Computing Division Head

The Computing Division is providing resources for the design and construction of the Data Acquisition System (WBS 2.7) and for beam simulations (WBS 2.0). This responsibility includes both hardware and software.

The CD Head or a designee acceptable to the Laboratory Associate Director for Research is a member of the Project Management Group. The CD Head advises the Associate Director for Research on approval of the sections of the NOνA Memoranda of Understanding that are relevant to CD resources and funds. The CD Head advises the Associate Director for Research on approval of the PMP and the Cost/Schedule Plan (CSP) and concurs with these approvals.

The CD provides Fermilab Personnel and technical resources for the data acquisition parts of the project. The CD Head and her/his designees may make long-term assignments of CD personnel directly to the project in consultation with the Project Manager and in accordance with the CSP. The NOνA Project Manager, in consultation with CD representatives and relevant L2 managers, assign CD personnel to achieve the agreed upon scope of work in the CSP. The CD Head maintains line management responsibility for these CD employees.

The CD also provides support to the project through CD technical resource groups. This is done in accordance with the CSP via specific work plans or NOνA Memoranda of Understanding. The CD Head maintains direct line management responsibility for such CD resources.

Since the CD is providing Fermilab labor needed to achieve the project schedule goals in the area of trigger and data acquisition, labor shortfalls must be reported in a timely fashion. The CD head or designee will advise the Project Manager and Laboratory Associate Director for Research on the availability and sufficiency of labor resources to meet the project plan and report to the NOνA PMG any mismatch in the availability of labor resources and the requirements of the CSP. In the event of any mismatch in the availability of labor resources and the requirements, the Project Manager will conduct a schedule impact study and will consider possible workarounds and propose a schedule variance as appropriate to the Laboratory Associate Director for Research as required by the project controls in the event of a schedule impact.

3.9 Fermilab Technical Division Head

The Technical Division (TD) is providing resources for the design and construction of accelerator components in support of the NOνA project. The TD Head or a designee acceptable to the Laboratory Associate Director for Research is a member of the Project Management Group. The TD Head advises the Associate Director for Research on approval of the sections of the NOνA Memoranda of Understanding that are relevant to TD resources and funds. The TD Head advises the Associate Directors for Research and for Accelerators on approval of the PMP and the Cost/Schedule Plan (CSP) and concurs with these approvals.

The TD Head and her/his designees may make long-term assignments of TD personnel directly to the project in consultation with the Project Manager as appropriate, and in accordance with the CSP. The TD Head maintains line management responsibility for these TD employees.

The TD also provides support to the project through TD technical resource groups. This is done in accordance with the CSP via specific work plans or NOνA Memoranda of Understanding. The TD Head maintains direct line management responsibility for such TD resources.

Since the TD is providing Fermilab labor needed to achieve the project schedule goals labor shortfalls must be reported in a timely fashion. The TD head or designee will advise the Project Manager and Laboratory Associate Directors for Research and for Accelerators on the availability and sufficiency of labor resources to meet the project plan as indicated in the CSP.

3.10 Facilities Engineering Services Section Head

The Facilities Engineering Services Section (FESS) is providing significant resources for the Far Detector experimental hall and associated site, subproject WBS 2.1. FESS is responsible for the design work, bid package preparation, supervision of some contracts, inspection and acceptance of the work comprising the far site construction subproject.

The FESS Head or a designee acceptable to the Laboratory Associate Director for Research is a member of the Project Management Group. The FESS Section Head advises the Associate Director for Research on the approval of the NOνA Baseline design as it affects the far detector site and the support of the components it has provided, and on scheduling issues. The FESS Section Head advises the Associate Director for Research on approval of the sections of the NOνA Memoranda of Understanding that are relevant to FESS resources and funds. The FESS Head advises the Director on approval of the PMP and the Cost/Schedule Plan (CSP).

FESS is the primary source of Fermilab manpower and technical resources for the far detector site subproject. The FESS Head and her/his designees may make long-term assignments of FESS personnel directly to the project in consultation with the NOνA Project Manager in accordance with the CSP. The Project Manager, in consultation with FESS representatives, then deploys these people to achieve the project goals, reporting changes in assignments to the FESS Head. The FESS Head maintains line management responsibility for these FESS employees.

FESS provides support to the NOνA project through its departments. This is done in accordance with the CSP via specific work plans or NOνA Memoranda of Understanding. The FESS Head maintains direct line management responsibility for such FESS resources.

Since FESS is the primary source for providing the Fermilab labor needed to achieve the project schedule goals in the area of the far detector site, labor shortfalls or contractor delays and problems must be reported in a timely fashion. The FESS head or designee will advise the Project Manager and Laboratory Associate Director for Research on the availability and sufficiency of labor resources to meet the project plan and report to the NOνA PMG any mismatch in the availability of labor resources and the requirements of the CSP. In the event of any mismatch in the availability of labor resources and the requirements, the Project Manager will conduct a schedule impact study and will consider possible workarounds and propose a schedule variance as appropriate to the Laboratory Associate Director for Research as required by the project controls in the event of a schedule impact.

3.11 Business Services Section Head, Procurement Department Head

Business Services provides support for procurement, financial transactions, and accounting activities necessary to accomplish projects. The Head of Business Services and the Head of the Procurement Department of Business Services will work with NOνA Management to accomplish the large number of procurements on schedule and to meet technical specifications. To this end, the Procurement Department has provided NOνA Management with specific guidance concerning the lead-time required to place various kinds of orders. In addition, Business Services has an agreement to support Open Plan™ Software from Deltek, which is used by NOνA to produce and status their schedule, as well as Cobra™ software that is used for earned value reporting. Business Services also provides a contact person to oversee major NOνA procurements in order to ensure competitive bidding, expedite the procurement process and to communicate progress and concerns to Project Management.

3.12 Environment, Safety, and Health (ES&H)

Safety will be integrated into all aspects of work per Fermilab's DOE-approved Integrated Safety Management program. Analysis is underway to document any safety hazards/concerns that will be addressed in the Preliminary Safety Assessment Document (PSAD). Work at the far detector site in Minnesota will include surface disturbance and new construction activities and will be performed in accordance with all state and local guidelines. The state of Minnesota requires that an Environmental Assessment Worksheet (EAW) be completed to determine if a further Environmental Assessment (EA) will be required. The EAW has been completed but further evaluation remains to determine if an EA is required. The Minnesota Pollution Control Board has concluded that the liquid scintillator to be used by NOνA is not a hazardous substance, so no problems are anticipated.

Prior to sustained operations, a Safety Assessment Document (SAD) will be written and approved by the site office. Updates to the existing Accelerator Division (AD) SAD and the NuMI/MINOS SAD will be prepared and approved prior to commissioning the accelerator and NuMI Beamline.

Activities conducted at universities will adhere to the ES&H policies and procedures of those specific institutions. The annual Statements of Work (SOW) signed between the institution and the NOνA project will identify a responsible safety person for NOνA activities at each institution.

Activities taking place at Fermilab that are centered in the Particle Physics Division and will follow the ES&H procedures of PPD. Activities taking place at Fermilab that are centered in the Accelerator Division will follow the ES&H procedures of AD. Should there be any NOνA activities in other Fermilab Divisions, the ES&H procedures for that Division shall be adhered to. Regular safety audits are conducted in accordance with each division's normal ES&H practices.

Activities conducted at the Far Detector Site will adhere to the ES&H policies and procedures of the University of Minnesota. The PPD Senior Safety Officer (PPDSSO) has overall ES&H oversight responsibility for the NOνA Project. The PPDSSO coordinates any activities and facilitates the resolution of any issues that cut across various Divisions and institutions.

3.13 NOνA Spokespersons

The NOνA Spokespersons provide the means of contact between the NOνA Collaboration and the Laboratory. They speak for the Collaboration and represent the Collaboration in interactions with the Laboratory. The NOνA Spokespersons are responsible for all aspects of the NOνA Experiment, including the operation of the NOνA detector, the analysis of data and production of physics results. The Spokespersons are selected by the Collaboration. In doing so, the Collaboration consults with the Fermilab Director and he/she concurs in the selection. Scope changes that have the potential to change the physics reach or physics capability of the NOνA experiment, but which do not affect the mission need, will be initiated by the spokespersons and approved by the Fermilab Director. The Spokespersons, representing the Collaboration, seek approval for all scope changes with the potential to have a significant impact on the physics capability of the detector by making scientific proposals to the Fermilab Director. The Fermilab Director may seek the advice of the Physics Advisory Committee when considering these proposals. The Fermilab Director approves all such scope changes, those that increase the scope as well as those that reduce it. Depending on the cost of the proposed change, its impact on the NOνA Project schedule, or its interaction with other laboratory projects, programs and priorities, the Fermilab Director may need to seek approval of the change from the DOE.

3.14 NOνA Project Manager

The NOνA Project Manager (PM) has the responsibility and authority to manage the NOνA Project to the approved scope, cost, and schedule. The Director of Fermilab appoints the PM with the concurrence of the NOνA collaboration. He/she reports to the Fermilab Director (or his/her appointed representative). A non-Fermilab NOνA collaborator may be appointed as the Project Manager after receiving a Guest Scientist appointment at the Laboratory.

The Project Manager is responsible for developing and coordinating support for the project from various organizations including the NOνA Project, other units within the laboratory, and institutions in the Collaboration. This support includes engineering and design, procurement and fabrication, ES&H support, administration, financing, and scheduling. He/she represents the NOνA Project in interactions with the NOνA Collaboration, FNAL, DOE, NSF, U.S. Institutions participating in the NOνA Project and foreign institutions and funding agencies participating in the NOνA Project.

The responsibilities of the Project Manager include:

a) Provide general administration, planning, organization and control on a day-to-day basis to complete the NOνA Project safely, on schedule and within the authorized budget;

b) Maintaining and updating the NOνA Project baseline cost and schedule plan;

c) Implementing and maintaining the Earned Value System;

d) Appoint Level 2 Managers who are responsible for coordination and management within each detector subsystem. The Level 2 Managers will serve with the PM's continuing concurrence;

e) Providing Quality Assurance, Risk Assessment/Management, Value Engineering and Configuration Management for the NOνA Project;

f) Maintain close communication with the Fermilab Director or his/her delegated representative on the progress of the NOνA effort, and report promptly any problems that may benefit from the joint efforts of the PM and Fermilab management;

g) Negotiate and sign the Institutional MOUs representing agreements between the NOνA Project and the NOνA collaborating institutions specifying the deliverables to be provided and the resources available on an institution-by-institution basis;

h) Publish a monthly report on the activities, issues, performance and fiscal status of the NOνA Project;

i) Make periodic reports to the NOνA Collaboration to ensure that the Collaboration is fully informed about important issues.

The Project Manager has the responsibility of completing the Project on schedule, on budget, and within the agreed upon scope by managing the designated resources of the Laboratory and, in consultation with the Spokesperson, the designated resources of the Collaboration. He/she is responsible for monitoring expenditures of US and non-US funds. He/she tracks and reports deviations from baseline schedules and costs as specified in the Project Management Plan.

3.15 NOνA Deputy Project Manager

The Deputy Project Manager will have the full authority of the Project Manager, in the event of the PM's temporary absence. The Deputy Project Manager will normally assist in the management of the project. The Project Manager may delegate certain specific responsibilities to the Deputy Project Manager. The Project Manager, with the consent of the Laboratory Director, appoints the Deputy Project Manager.

3.16 NOνA Associate Project Manager

The NOνA Project Manager has delegated to the Associate Project Manager primary responsibility for management of the improvements and upgrades to the accelerator complex required to support the NOνA project. The Associate Project Manager serves as the primary point of contact within the NOνA management team for the AD and TD Heads on issues relating to the accelerator upgrades. The Associate Project Manager will also normally assist in the management of the project. The Project Manager may delegate certain specific responsibilities to the Associate Project Manager beyond management of the accelerator systems. The Project Manager, with the consent of the Laboratory Director, appoints the Associate Project Manager.

3.17 Technical Coordinators

The Technical Coordinators, including the NOνA Project Mechanical Engineer, the Project Electronics Engineer and the Project Chemist are appointed by the Project Manager in consultation with the NOνA Spokespersons. The Technical Coordinators report to the Project Manager and assist in the coordination, evaluation, and decision-making process for technical issues across the entire Project as well as in preparing the standards and procedures required to manage and execute the project. The Technical Coordinators also play an important role in project integration since they have responsibilities that span multiple Level 2 systems.

3.18 NOνA Project Subproject Managers

The Project Manager in consultation with the NOνA spokesperson appoints the Level 2 managers. They report to the PM. The Project Manager in consultation with the relevant Level 2 managers appoints the Level 3 managers. Level 3 managers may chose to elect, in consultation with the Level 2 managers and Project Management, Level 4 managers and delegate some responsibility to them. The Subproject Managers manage and direct their subprojects and report to the Project Manager. They are directly responsible for generating and maintaining the cost-estimate, schedule, and resource requirements for their subprojects. They are responsible for meeting the goals of their subproject within the accepted baseline cost and schedule. The Subproject Managers are in the line management for the project and are responsible for completing their subprojects safely and with respect for the environment.

3.19 NOνA Collaborator Responsibilities

The responsibilities of NOνA Collaborators are specified in comprehensive NOνA Memoranda of Understanding (MoU). A multi-year MoU details the work that the Collaborator has agreed to do for the Project, and includes a list of the personnel involved, and significant milestones. These agreements are updated yearly through Statements of Work (SOW) that specify the funding and commitments for the next Fiscal Year. They are negotiated by the NOνA Project Manager and are approved by the appropriate responsible parties for the collaborating institution, the heads of relevant Divisions, and the Associate Director for Research. The Project Manager has responsibility for coordinating and managing all Collaboration-wide resources identified by these MoU's and SOW's.

3.20 Advisory Functions

<u>NOνA Technical Board</u>

The Project Manager serves as the chair of the NOνA Technical Board that meets frequently to discuss technical and management issues in the Project and is advisory to the Project Manager. The group is comprised of the NOνA Spokesperson, Project Manager, Deputy and Associate Project Manager, Technical Coordinators, the Level 2 Subproject Managers, additional personnel from the Project Office, and others as the need arises. The WBS Level 3 Subproject Managers may participate in these meetings. The Technical Board advises the Project Manager on all aspects of the project including any changes to the cost, scope or schedule. The meetings also provide a convenient mechanism for the dissemination of information, discussions of risk, ES&H, QA and value engineering.

NOνA Risk Management Board

The Project Manager serves as the chair of the NOνA Risk Management Board that meets frequently to discuss technical and management issues in the Project and is advisory to the Project Manager. The group is comprised of the NOνA Project Manager, Deputy and Associate, Technical Coordinators and Level 2 Subproject Managers. The Technical Board is responsible for reviewing and recommending approval or modification of risk analyses and risk mitigation strategies, as requested by the Project Manager and assisting in the development of risk abatement strategies as needed.

NOνA Project Management Group

The Laboratory Associate Director for Research chairs a Project Management Group (PMG) that meets as required, but at least monthly, to monitor the progress of the project. Those who have responsibility for the Project and by those who have authority to redirect resources within the Laboratory and the Collaboration attend the meetings. The group normally consists of the NOνA Spokespersons, the NOνA Project Manager, Deputy and Associate, the Heads of participating Divisions and Sections, ES&H Section Head or designee, the Laboratory Deputy Director, the Associate Director for Research, the Associate Director for Accelerators, and other representatives of Fermilab and NOνA. The PMG also serves as the Change Control Board for the project.

NOνA Executive Committee

The NOνA Executive Committee consists of the leaders chosen by the NOνA collaboration, along with the NOνA spokesperson, Project Manager, Deputy Project Manager and the head of the NOνA Institutional Board, to deal with collaboration and physics issues related to the experiment. It has strong university representation. The Executive Committee advises the NOνA Spokespersons on all aspects of NOνA including collaboration issues relating to the NOνA Project.

NOνA International Finance Committee

The NOνA International Finance Committee consists of the NOνA Spokespersons and a funding agency representative from each non-US country providing funding or in-kind contributions to NOνA. Since much of the U.S. contribution comes through Fermilab, the Fermilab Associate Director for Research is the U.S. funding agency representative on the committee and serves as chairperson. During the construction phase, the NOνA Project Manager and Deputy Project Manager are also members. DOE representatives are invited to attend. This Committee oversees the use of financial contributions by these groups to the costs associated with the construction of the NOνA Project and operation of the NOνA detector and experiment.

4 COOPERATIVE AGREEMENT

The DOE has received an unsolicited proposal from the University of Minnesota for a cooperative agreement to conduct research on neutrino oscillations as part of the NOvA collaboration. As part of the research program the University proposes to construct the far detector enclosure on University owned land, to operate the building, to be responsible for security and ES&H, and to participate in the calibration's data-taking, maintenance of the NOvA detector and the subsequent data analysis. This financial assistance award would include both a portion of the NOvA TPC (construction of the detector enclosure) and subsequent research activities. The OHEP, supported by the DOE NOνA project staff at

the Fermi Site Office, will provide oversight for both the cooperative agreement and the detector fabrication funded as a Major Item of Equipment (MIE) and any interactions between the two efforts.

There is a key interface between the NOνA Project Manager and the recipient of the Cooperative Agreement Award to construct the far detector enclosure. This interface will be managed to ensure coordinated execution of authorities among the parties, and to maintain adequate communication, work authorization, project controls and reporting to cover design, construction and oversight activities.

4.1 Integrated Construction Team

An integrated construction team has been formed to manage the construction of the far detector enclosure. The Integrated Construction Team is shown in Figure 4.1. The Construction Management Office will be jointly run by the NOνA L2 Manager for the Far Site and Building as well as a representative from the University of Minnesota. The Construction Management Office will report up through both the NOνA Project Office and the University of Minnesota Office of Facilities who will both report up through their respective line management to the Department of Energy. The Construction Management Office will have defined engineering, design, procurement and legal resources available to draw on.

4.2 Operation of the Far Detector Enclosure

Once NOνA has obtained beneficial occupancy of the far detector enclosure, responsibility for operation of the enclosure will fall to the recipient of the Cooperative Agreement. Operation of the far detector enclosure will be funded through the Cooperative Agreement but will not be part of the NOνA Project or contribute to NOνA's TPC. For the balance of the NOνA Project, the status of the enclosure operations will be reported through the NOnA Project, as shown in Figure 4.2. Once the NOνA Project has been closed out, another means of managing operations will have to be developed.

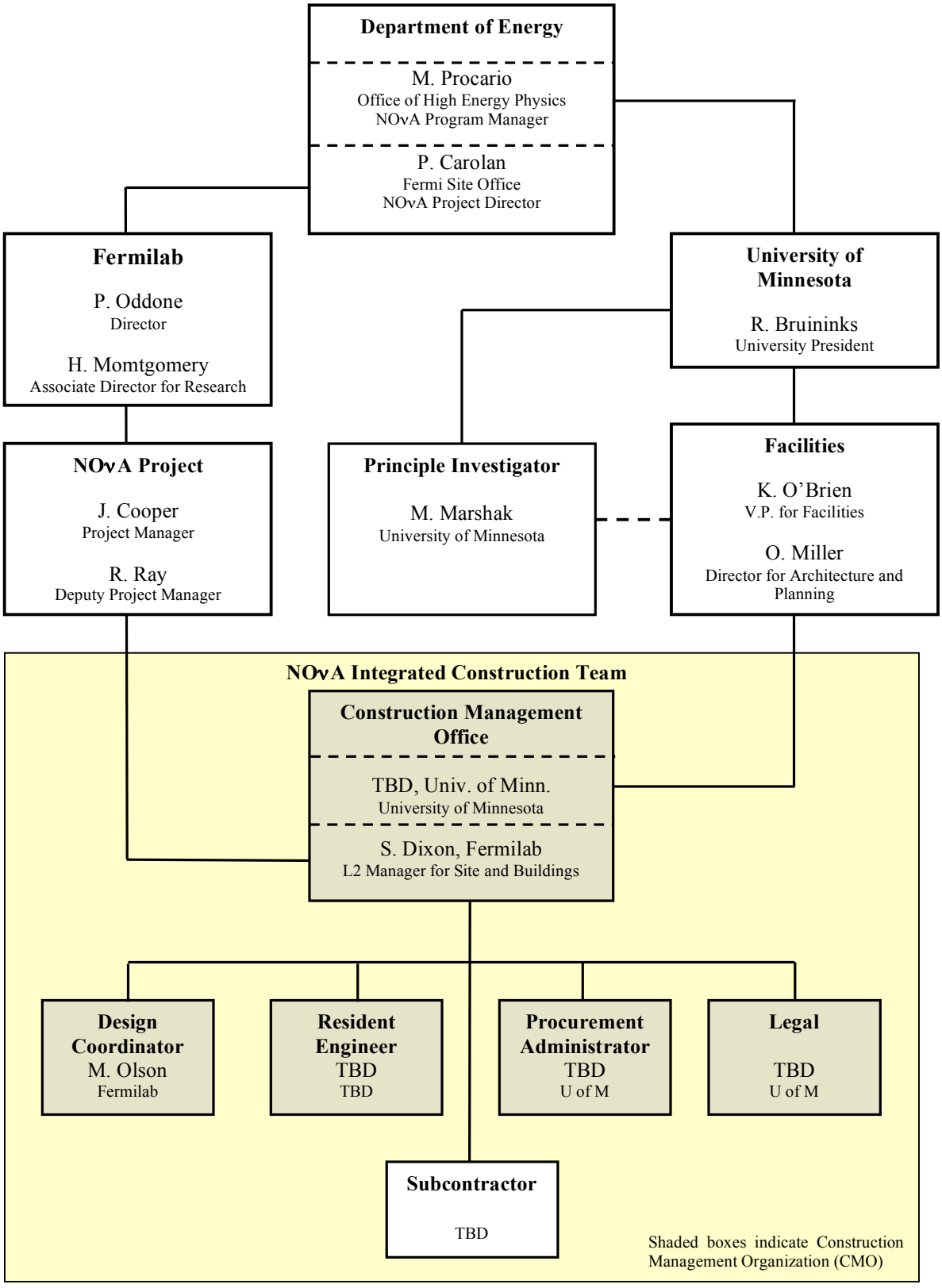

Figure 4.1 Organization chart for the NOvA Integrated Construction Team.

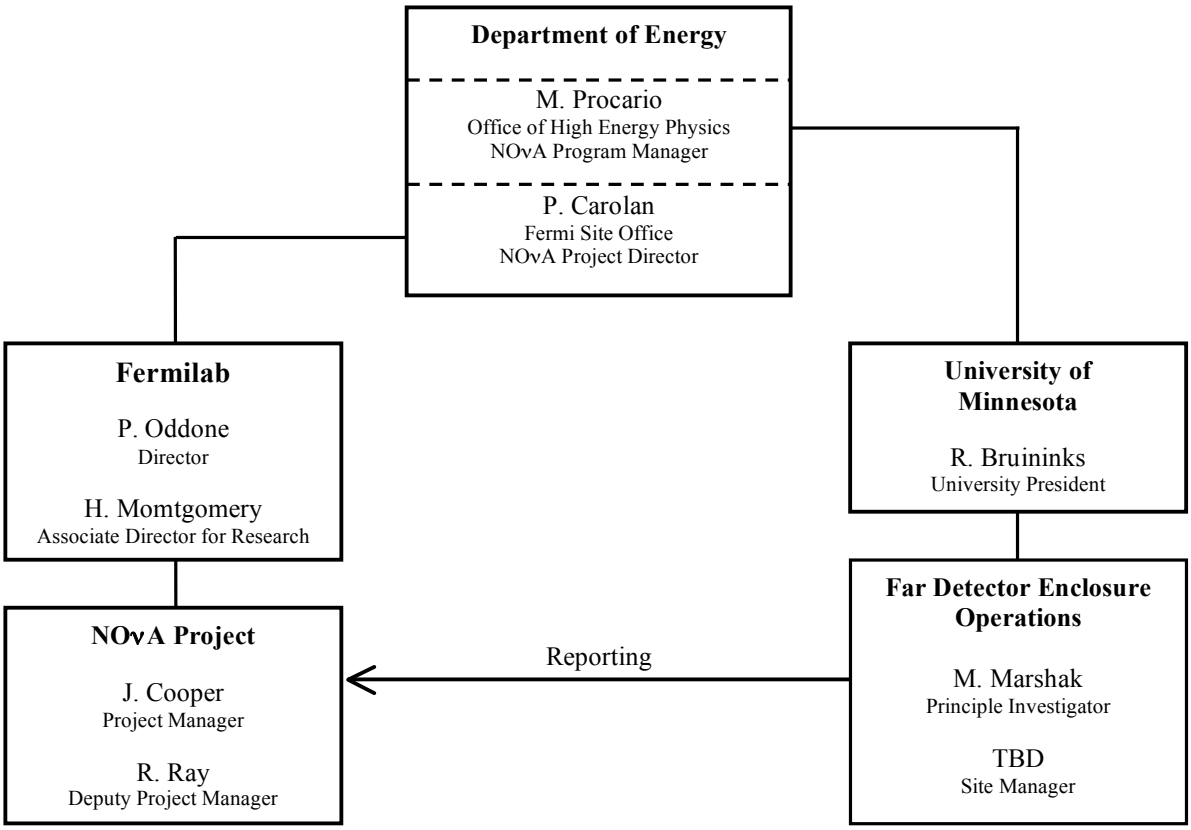

Figure 4.2 Organization chart for operation of the Far Detector Enclosure during the life of the NOνA Project.

5 WORK BREAKDOWN STRUCTURE

All work required for completion of the Project is organized into a Work Breakdown Structure (WBS), a hierarchical ordering of tasks in outline-like form. The WBS constitutes a complete definition of the scope of the project and forms the basis for its planning, execution, and control. The WBS is the basis for a resource-loaded cost and schedule (RLCS) with appropriately linked tasks. The schedule contains Materials and Services (M&S) costs, labor costs, and contingency on a task-by-task basis, as well as a series of project milestones that aid in the estimation of the project end date.

The major systems that comprise the Project are represented at WBS Level 2. They are listed below. The NOνA Institutions that are contributing to the various WBS tasks are shown in Table 5.1.

WBS 2.0 Accelerator & NuMI Upgrades
WBS 2.1 Far Detector Site and Building
WBS 2.2 Liquid Scintillator
WBS 2.3 Wave Length Shifting Fiber

WBS 2.4 PVC Extrusions
WBS 2.5 Extrusion Modules
WBS 2.6 Front-End Electronics
WBS 2.7 Trigger/DAQ
WBS 2.8 Near Detector Assembly
WBS 2.9 Far Detector Assembly
WBS 2.10 Project Management

The task-based WBS extends downward through many additional levels to facilitate cost, schedule and resource planning. The WBS Level 2 structure is described below.

WBS 2.0 Accelerator & NuMI Upgrades
This level 2 summary element includes the design, procurement, QA, construction and installation of equipment required for improvements in the Main Injector and Recycler accelerators, and beamline/target hall improvements at the NuMI facility.

WBS 2.1 Site and Building
This Level 2 element covers the design and construction of the Site and far Detector Enclosure and Building.

WBS 2.2 Liquid Scintillator
This level 2 summary element covers the procurement, production, QA and shipping of the liquid scintillator required by the project for both the Near and Far Detectors.

WBS 2.3 Wavelength Shifting Fiber
This level 2 summary element covers the procurement, QA and shipping of wavelength shifting fiber.

WBS 2.4 PVC Extrusions
This level 2 summary element covers the procurement, QA and shipping of the PVC extrusions.

WBS 2.5 PVC Modules
This level 2 summary element provides for assembly and QA of the PVC modules for both the Near and Far Detectors, the design and construction of the manifolds and endplates, and shipping of the completed and tested modules to their respective detector sites.

WBS 2.6 Electronics Production
This level 2 summary element includes the Avalanche Photo Diode (APD) optical sensors, the thermo-electric (TE) coolers for the APDs, design and fabrication of the custom ASIC that amplifies and multiplexes the APD signals, the ADC that digitizes the signals and the FPGAs that zero suppress and time-stamps the data. Also included is the low-voltage system for the TE coolers and the front-end electronics, the high voltage system for the APDs and the design and construction of the cooling system to remove the

heat from the TE coolers. These systems will be provided for both the Near and Far Detectors.

WBS 2.7 Data Acquisition System

This level 2 summary element includes the hardware and software to record the data to archival storage and to control and monitor both the Near and Far Detectors. It includes the fiber, cable, switches and memory necessary to move and buffer the data, a PC farm for online filtering, local disk storage, a system for moving data to permanent storage at Fermilab, software and testing.

WBS 2.8 Near Detector Assembly

This level 2 summary element provides for the engineering design of the mechanical devices and tooling needed to install the NOνA Near Detector. Fabrication of the necessary tooling, installation and commissioning of the near Detector in its underground location at Fermilab is also included.

WBS 2.9 Far Detector Assembly

This level 2 summary element provides for the engineering design of the mechanical systems and tooling needed to install the NOνA Far Detector. Fabrication of the necessary tooling, installation and commissioning of the detector in the detector building in Northern Minnesota is also included.

WBS 2.10 Project Management

This Level 2 summary element consists of reviews, reports, site visits, local supervision, running technical board meetings, standards preparation, tracking and analysis, schedule preparation tracking and analysis, change control. It also includes procurement of relevant software and computers, the cost of running the project office and the salaries of non-scientists working on the project.

Table 5.1. Breakdown of NOνA institutions that are contributing to the various WBS tasks.

WBS	Description	Contributing Institutions
1.0, 2.0	Accelerator and NuMI Upgrades	Fermilab, UT-Austin
1.1, 2.1	Far detector Site and Building	Fermilab, Minnesota
1.2, 2.2	Liquid Scintillator	Fermilab, Indiana, SMU
1.3, 2.3	Wavelength Shifting Fiber	Michigan St., Caltech, UCLA. UT-Dallas
1.4, 2.4	PVC Extrusions	Argonne, Fermilab
1.5, 2.5	Extrusion Modules	Fermilab, Michigan St., Minnesota
1.6, 2.6	Front-End Electronics	Caltech, Fermilab, Harvard, Indiana, Minnesota, Virginia
1.7, 2.7	Trigger/DAQ	Caltech, Fermilab, Harvard, Minnesota, Virginia
1.8, 2.8	Near Detector Assembly	Argonne, Fermilab, Minnesota
1.9, 2.9	Far Detector Assembly	Argonne, Fermilab, Minnesota, Tufts
1.10, 2.10	Project Management	Argonne, Caltech, Fermilab, Harvard, Indiana, Michigan, Minnesota

6 TECHNICAL, SCHEDULE, AND COST BASELINE

6.1 Technical Baseline and Technical Definition of Project Completion

The PEP contains the official scope of the Project, the technical baseline for which is further described in the NOνA Technical Design Report. The technical definition of "Completion" for each of the NOνA subprojects is shown in Appendix B Table 1. Project Completion is based upon:

- Full installation of the components required for accelerator and NuMI upgrades and modifications, assembly of the NOνA detectors.
- Complete installation of the trigger and data acquisition system.
- Integration of all components.
- Checkout with sources or cosmic rays to verify functionality.
- Acceptance of all work performed for the far detector building and outfitting in accordance with the conditions set forth in the corresponding contracts.

6.2 Project Schedule

A comprehensive schedule of work to design, construct, assemble, and install the accelerator and NuMI upgrades and modifications and to design, construct, assemble, install and commission the NOνA detector is maintained to facilitate management of the Project. It is comprised of detailed schedules for the development of each subsystem in the project and includes the resources (cost, manpower) required for each step. Based on these details, an overview of the project has been fashioned, complete with cost and manpower needs as a function of time and a series of milestones spread throughout the project. The WBS structure is defined through this schedule.

Schedule Methodology

The schedule is assembled using the computer program Open Plan™, a Deltek product. Level 2 managers are responsible for the generation and maintenance of the schedules for their subsystems, in collaboration with the NOνA Project Office.

The schedule is built of tasks of various durations and milestones that are linked to describe the flow and interdependency of the work. The manpower required to complete each task is specified. Separate allocations are made for various types of technical personnel – including mechanical and electrical engineers, designer/drafters and technicians, as well as physicists, both for Fermilab and non-Fermilab employers. Thus, profiles in time of various work groups are readily obtained to aid in the establishment of manpower requirements and the allocation of personnel as the Project evolves. By entering the average hourly labor cost for each type of manpower, labor cost profiles are extracted for each work group as well as the total labor cost for each subproject and for the entire Project.

The M&S funds needed to complete each task are determined and assigned directly to the tasks in the schedule. Cost plans for each subproject and for the full project are then derived. Using this information, a consistent and viable work plan is established by making appropriate adjustments to the schedule to yield an overall cost plan that matches the profile of funds available from the Laboratory and other sources, and a manpower plan that can be supported by the Laboratory. We note that for all M&S and labor estimates, a detailed Basis of Estimate (BoE) is provided that describes the foundation

of and justification for the resources assigned to each task in the schedule. Cost Books have been prepared that provide the source documentation (quotes, invoices, etc.) and supplementary information used in preparing the BoE.

The scheduling program identifies the critical path (or paths) to completion of the Project. This feature calls attention to those tasks that have no 'float' or slack and that must therefore be carefully monitored to prevent delay in project completion. Knowledge of the critical path facilitates changes to optimize the work and to hasten completion.

Project Schedule Milestones

A baseline schedule that is consistent with the available funding and manpower resources has been assembled. The Subproject Managers and the Project Manager monitor the schedule. A hierarchical set of milestones, so called "tiered milestones," has been established to track progress in the Project. At the lowest level, Level 3, a comprehensive set of milestones is distributed throughout the duration of each subproject. The Project Manager and the Fermilab management jointly monitor and hold change control authority for the Level 3 milestones. These Level 3 Milestones are listed in Table 5 of Appendix B. The Level 2 milestones are derived from a subset of the Level 3 milestones; the DOE NOνA Project Director monitors and holds change control authority for Level 2 milestones. These are shown in Appendix B Table 4. The Level 1 milestones are derived from these. The Office of Science Acquisition Executive monitors and holds change control authority for the Level 1 milestones as described in the PEP. The Level 1 milestones are listed in Appendix B Table 3.

6.3 Labor Requirements

The labor requirements are extracted from the resource-loaded schedule and are given in Appendix B Table 6 in units of person-years. The categories shown include all collaboration-wide physicist personnel (Physicist), technical personnel provided by collaborating institutions (Technical-University), and technical personnel provided by Fermilab (Technical-Fermilab). Note that physicist personnel, while fully integrated as a resource in the project schedule, are funded by non-Project sources and are not included in the Project cost.

6.4 Project Cost

The cost estimate for the Project covers all Materials & Services (M&S) and Salaries, Wages and Fringe Benefits (SWF) costs for the Project.

Cost Estimate

The M&S costs and labor resources are estimated at the lowest (task) level in the Project Schedule. Contingency for labor and M&S is also estimated at the task level based on the guidelines described below. The Project Manager is able to review the costs at any level of detail by examining the roll ups of tasks within a given class. The Project Manager in consultation with any technical experts that are deemed necessary reviews the cost estimates provided by the Subproject Managers. The costs in the schedule are given in FY`07 dollars. Appropriate overhead and escalation is done external to Open Plan™, within the Cobra™ project cost management and reporting software that is used to compute earned value. It is foreseen that all project tracking and reporting will be done within the Cobra™ software for the duration of the Project.

M&S Contingency Estimation

Contingency estimates are made by Level 3 Subproject Managers at the lowest available level. Contingency is based on detailed estimates of designs where available, and on the experience of the Subproject Managers and the engineering staff directly involved with the subsystem where a conceptual design exists. The Project Manager has provided guidelines for the estimation of the contingency (NOνA-doc-616). Separate guidelines are provided for contingency on M&S and Labor.

6.5 Cost Summary

TBD

7 CHANGE CONTROL THRESHOLDS

Any change to the Project that does not alter the scope of the Project as defined above does not require a new proposal to be submitted to the Laboratory. Although the scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments, or schedule impact are considered changes to the project plan that may require authorization to implement.

7.1 Change Control Procedures

Formal change control procedures will be used to track technical, schedule, and cost changes in the Project. Each such change requires the preparation of a Project Change Request (PCR) form. The Project Manager will review each Project Change Request. The NOνA PMG will function as a Level 3 Change Control Board for the project, and the Level 4 CCB will consist of the NOνA Project Manager, Deputy Project Manager, Associate Project Manager and Technical Coordinators. The NOνA Project Manager will maintain current records of all Change Requests and their disposition

7.2 Technical Change Control Levels

The Subproject Manager must approve minor technical changes consistent with the baseline technical design and affecting just one subproject.

The Project Manager must approve technical changes that affect more than one subproject but that do not diminish performance.

Major technical changes that are a significant departure from the baseline technical design must be approved by the Project Manager who brings them to the PMG for final disposition. The Project Manager acts as advocate for such changes before the PMG.

Technical changes that affect ES&H requirements, impact accelerator systems, or changes in scope that affect physics capabilities require a Change Request be submitted for consideration by the NOνA PMG and approved by the Associate Director for Research.

7.3 Schedule Change Control Levels

The Subproject Manager must approve changes that result in the delay of a Level 5 milestone by more than a month.

The Project Manager must approve changes that result in the delay of a Level 4 milestone by more than a month.

Changes that result in the delay of Level 3 Director's Milestones require a Change Request be submitted by the Project Manager for consideration by the NOνA PMG and approved by the Associate Director for Research. The response to such a Change Request may be to initiate a plan to reallocate resources to recover the schedule, a plan to stage or de-scope the detector, or rescheduling of the milestone.

7.4 Cost Change Control Levels

The Subproject Manager must approve changes to the cost of a single item or task exceeding $10K.

The Project Manager must approve changes to the cost of a single item or task exceeding $50K.

Changes in the cost of a single item or task exceeding $200K or a $500K increase in the project base cost during the previous 12 months require a Project Change Request be submitted for consideration by the NOνA Project Manager to the NOνA PMG and approved by the Associate Director for Research.

7.5 Change Control Summary

Table 6.1 summarizes the Fermilab change control thresholds and responsibilities. Table 6.2 summarizes the DOE change control thresholds and responsibilities described in the PEP.

Table 6.1 Fermilab technical, schedule, and cost baseline control levels.

	Fermilab Associate Director (Level 3)	NOνA Project Manager (Level 4)	Subproject Manager (Level 5)
Technical	Major technical changes that are significant departures from the technical baseline. Changes that affect ES&H requirements or impact PoT projections by more than 10%. Out-of-scope changes to upgrade physics capabilities.	Related technical changes to multiple subprojects that do not diminish performance.	Minor technical changes to a single subproject that does not diminish performance.
Schedule	Any change that results in the delay of a Level 3 Director's milestone.	Any change that results in the delay of a Level 4 milestone by more than one month.	Any change that results in the delay of a Level 5 milestone by more than one month
Cost	Increase in the cost of a single item by more than $200k. Increase in the Project base cost exceeding $500k during the previous 12 months.	Increase in the cost of a single item by more than $50k.	Increase in the cost of a single item by more than $10k.

8 RISK MANAGEMENT

Project risk in NOνA is mitigated through a structured and integrated process for identifying, evaluating, tracking, abating, and managing risks in terms of three risk categories: cost, schedule and technical performance. A Risk Management Board, chaired by the Project Manager, meets regularly to identify risks and develop mitigation plans.

Any project faces both threats and opportunities and must strive to exploit the opportunities while ensuring that the threats do not derail the project. Numerous informal and formal approaches are used for identifying threats and opportunities, assessing their likelihood, prioritizing them for possible mitigation or exploitation, and devising strategies to do so. The key to successful risk management is alertness to potential risks and a deliberate approach to accepting, preventing, mitigating, or avoiding them. The NOνA project becomes aware of potential risks in many ways, notably during work planning, meetings, reviews, and via lessons learned from others. Risk has been managed during the planning and design phase by implementing appropriate actions, such as ensuring adequate contingency and schedule float, pursuing multiple parallel approaches, and/or developing backup options. Accelerator and detector construction projects are well within the experience and expertise of the NOνA collaboration. Every effort has been made to specify these projects in a manner that reduces the risk to an acceptably low level.

The technical risks facing the NOνA Project are no greater than those facing other HEP projects; risks that are identified will be managed as early as possible to assure that they do not derail the timely completion of the project or stress its budget in unexpected ways. The initial risk assessment indicates that the project will have low cost and technical risk exposure and some moderate schedule exposure. The schedule exposure is the result of the quick startup time required of the project and possible delays in funding for the far detector building.

The NOνA Risk Management Plan, NOνA-doc-185, is under configuration management and can be accessed at here.

Table 6.2 DOE Technical, schedule and cost baseline control levels from the PEP.

	Secretarial Acquisition Executive (Level 0)	Acquisition Executive (Level 1)	DOE NOνA Project Director (Level 2)
Technical	Any change in scope and/or performance that affects mission need requirements.	Addition or deletion of any major subsystem that does not affect mission need requirements.	
Schedule	6 month or greater cumulative increase in the original project completion date.	Any change to a Level 1 milestone > 6 months.	Any change to a Level 2 milestone.
Cost	Increase in excess of $25M or 25% (cumulative) of the original cost baseline.	Any increase in Total Project Cost and/or increase in Total Estimated Cost.	Any cumulative use of contingency in excess of $500k.

* Changes must be recommended at all applicable lower levels prior to being forwarded to the next higher level for consideration.

9 PROJECT CONTROLS SYSTEM

9.1 Introduction

This chapter summarizes the NOνA Performance Management System Description (PMSD) document that describes the management systems that the Project will use to monitor the cost and schedule performance and the technical accomplishments of the Project. The significant interfaces that exist among the various management systems are noted in the following individual narrative descriptions. Although these systems are described separately they are mutually supportive and will be employed in an integrated manner in order to achieve the project objectives. As conditions change during the evolution of the project, the management systems will be modified appropriately so as to remain responsive to the needs for project control and reporting. Consequently, while the policy and objectives of each management system will remain fixed, the methods, techniques, and procedures that will be employed by the Project may change as conditions dictate, over the life of the project.

The Work Authorization and Contingency Management System and the Project Control System described in this chapter define the management and control procedures required by the Laboratory.

9.2 Guidelines and Policies

The Contingency Management System and the Project Control System employed by the Project will be consistent with the Fermilab Director's Policy No. 12, dated January 1, 1999.

The following policies are applicable for the NOνA Detector Project:

- All Project work is organized in accordance with the WBS.
- Formal (and informal) reviews by experts are used to establish baseline specifications and designs.
- Established cost, schedule, and technical baselines are used for measuring project performance. Technical baselines are maintained in the Technical Design Reports describing the current design implementation for each system included in the scope of the Project. These will be updated as required to reflect approved changes and will be controlled documents once an initial technical baseline is approved.
- Changes to the approved cost, schedule and technical baselines proceed via a Change Request process described below.
- A performance management system that features performance measurement based on cost accounting and scheduling is used to control the project and to provide forecast and feedback information to management. In particular, Earned Value will be calculated via the project cost management and reporting tool Cobra™, which uses as inputs the Open Plan™ NOνA Project schedule as well as the Fermilab financial project accounting system.
- The decision-making apparatus includes regular meetings between the Project Manager and the Subproject Managers. These meetings help to identify and resolve interface issues within the project.
- Quality assurance, safety analysis and review, and environmental assessment are integral parts of the Work Authorization and Project Control.

9.3 Work Authorization and Contingency Management

The Director will make funds available to the Project on an annual basis following the receipt of the Initial Financial Plan from DOE. These funds will correspond to a financial plan and a funding profile to project completion as determined by the Director. The funding profile will include contingency in each year of the project.

The NOνA Project Budget Officer will establish cost accounts in the Fermilab financial accounting system following the NOνA WBS structure with the approval of the Fermilab Budget Office. The accumulation of M&S costs in these accounts will be initiated through purchase requisitions originating with the engineering and scientific staff assigned to the various subsystems. Signature authority levels will be provided to the Particle Physics Division Office by the Project Manager to assure that only authorized work is initiated.

At any time, the project contingency is the difference between the project Total Estimated Cost (TEC) and the Estimate at Completion (EAC). The Project Manager will hold the contingency and allocate it subject to the Project Control System described below.

The principles of contingency management that the Project will follow are as follows:

- The cost estimate for each subsystem will include contingency funds based on an assessment by the preparer, in conjunction with the PM, of uncertainties and risks associated with the budgeted cost;
- The actual use of contingency will be reflected in a new EAC to be updated periodically;
- All Change Requests that will require utilization of contingency, subject to the thresholds described earlier shall be submitted to the PMG for approval;
- All changes will be tracked with approved Change Requests and a record of all Change Requests will be maintained by the Project;
- Each fiscal year, the Project Manager will assign the contingency available in that year within the following guidelines:
    - The Project Manager may adjust the estimated cost of any WBS level 2 subproject by as much as $200K, as long as the Project TEC is not exceeded. If the change exceeds $200K, the Change Request must be approved by the PMG;
    - The use of contingency above the amount budgeted for the year requires that the NOνA PMG approve a Change Request.
- All changes from baseline cost shall be traceable.

9.4 Baseline Development

Baseline development includes management actions necessary to define project scope and responsibilities, establish baselines, and plan the project. Each subproject prepares a formal cost estimate and schedule. The subprojects all have defined Work Breakdown Structures (WBS) which are detailed subsets of the WBS, below level 2. In addition, technical specifications for each subproject are contained in the Technical Design Report. The NOνA Technical Design Report includes detailed technical descriptions of all accelerator and NuMI upgrades and modifications, all detector systems, the trigger and data acquisition systems, integration and installation, and commissioning.

9.5 Project Performance Measurement

Project Performance includes management actions after work commences that are necessary to monitor project status, report and analyze performance and available resources, and manage risk. Project performance aspects of the Project Control System consist of the following:

Funds Management

The detailed obligation plan for each WBS item is derived from the baseline schedule for the project that is funded at a rate consistent with the profile of funds from the Laboratory and other sources. This

top-down obligation plan is adjusted by Project Management as appropriate to reflect changes in the Laboratory funding profile.

Accounting

A record of all M&S obligations associated with individual WBS elements is maintained in the Fermilab financial system for tracking purposes. Each obligation is identified with the corresponding cost account, thereby enabling comparison of obligations with the Cost Estimate at that level. Monthly tracking reports are produced that show all purchasing activity at the cost account level in each subproject. For each item, as well as roll-ups to higher levels, the cost estimate, current-year allocation, year-to-date and project-to-date obligations and balances are displayed.

All NOνA Project M&S transactions are also associated with Fermilab work packages, generally at WBS level 5 or below. The Fermilab financial project accounting system is used to track and account for all obligations and subsequent costs at the cost account level, and facilitates reporting summarized at the cost account level. Monthly accounting reports depict obligation and cost details and summaries for all work packages or WBS categories at the appropriate level as determined by Project Management. The cost of labor in each WBS level 2 category in the NOνA Project is captured by reporting the fraction of effort of each individual involved in the work and transferring the salary cost to the corresponding cost account. Fermilab Divisions and Sections collect monthly FTE effort reports for all individuals to allow for crosschecks and corrections to salary costs, as necessary.

Performance Measurement and Analysis

The principle functions of performance measurement and analysis are to identify, quantify, analyze and rectify significant deviation from the plan as early as possible. Earned-value reporting will be accomplished through the use of the Cobra^{TM} software package.

Schedule Variance

At the end of each month, the detailed schedule for each subproject is examined for variances from the baseline schedule. This is accomplished by updating the 'actual' schedule on the basis of work performed in the period, and comparing the actual schedule to the baseline schedule. An extensive set of milestones for each subproject is also monitored. This is performed by Project Scheduler in conjunction with the WBS Level 2 and Level 3 Managers, and submitted to the Project Management for examination and review.

Changes that have a significant impact on the project, either by delaying completion or by affecting the cost or manpower plan of the project are identified for further analysis. A plan to rectify the problem is developed that may include:

- alteration of the schedule to optimize the work and reduce the delay,
- allocation of additional resources (funds or manpower) to shorten the time required to perform given tasks.

Any change that would alter the schedule, cost or personnel resources of work to be performed is subject to the controls described below.

Cost Variance

In approving a purchase requisition, the WBS level 2 managers will compare the proposed obligation with the balances remaining for that item and its parents at higher levels. If the obligation does not exceed the estimated cost, the manager may approve the requisition directly. However, if the obligation would require use of contingency on that item or at a higher level, the manager must formulate a plan to fund the item and attach the details to the requisition for approval by the Project Manager. In this fashion, use of contingency is approved prior to incurring the obligation. Cost variances that exceed the established thresholds are formally reported as provided in Section 6.

Each month, obligation performance is determined by comparing obligations to date with budgeted or allocated costs to date as indicated by the obligation-loaded schedule.

Resource Variance

On a monthly basis, the available funds and manpower resources are compared with those required in the schedule to identify shortfalls that could lead to schedule and/or cost variances. Any such variances will be brought to the attention of the NOνA PMG.

9.6 Change Management

Change management includes the actions necessary to ensure adequate control of project baselines, including the performance measurement baseline. Details regarding change control at DOE Levels 0 and 1 are contained in Section 7 of the PEP. Change Management aspects of the Project Control System consists of the following:

Out-of-Scope Changes

An out-of-scope change is a proposed change to the scope of the Laboratory-approved Project that would alter the physics capabilities of the detector in a major way or introduce a new detector system. The 'scope' of the project includes the design, construction and installation of the collection of systems or improvements to systems that have been granted Stage I approval by the Director. The scope of the project is defined by the proposal document that includes content equivalent to a Technical Design Report. Each individual system or an improvement to a system has an impact on the physics capability of the Project as a whole. This physics capability is also defined in the proposal. The scope of the project as an aggregate determines the physics capabilities of the upgraded detector.

Any out-of-scope change must be initiated by a formal proposal by the Spokespersons to the Director for consideration. In response to such a proposal, the Director may seek the advice of the Fermilab Physics Advisory Committee, the NOνA PMG and/or a Director's Review. Such a proposal may be granted Stage I approval, deferred for further clarification of the physics potential, technique, cost and/or schedule, or it may be rejected. Depending on the cost of the proposed change, its impact on the NOνA Project schedule, or its interaction with other laboratory projects, programs and priorities, the Fermilab Director may need to seek approval of the change from the DOE.

In-Scope Changes

Any change to the Project that does not alter the scope of the Project as defined above does not require a new proposal to be submitted to the Laboratory. Although the scope of the project is not affected, changes resulting in cost variations, changes of personnel assignments or schedule impact are

considered in-scope changes. The change management for in-scope changes is fully described above in the mechanism for baseline change control.

9.7 Reporting and Review

Monthly Progress Reports

The Project provides reports on a regular basis to Fermilab and DOE management. The objective of the reporting is to provide for the collection and integration of essential technical, cost, schedule and performance data into reports to aid in the monitoring and management of the Project.

All WBS Level 2 Managers submit monthly written reports to the Project Manager detailing specific progress on the pertinent subsystems. These reports summarize the activities of the previous month, describe activities planned for the upcoming month, and include comments and concerns. They are collected and summarized in a corresponding monthly report submitted to the Heads of the Particle Physics Division, the Computing Division, the Technical Division, the Accelerator Division, the Facilities Engineering Services Section and the Directorate that outlines progress, problems, and budget and schedule status, including comparisons of projected status versus actual status. The Directorate submits these reports to the DOE.

Technical Design Report

A comprehensive Technical Design Report has been written that includes detailed technical descriptions of all NOνA Project subsystems: accelerator and NuMI upgrades and modifications, detector components, trigger and data acquisition systems, integration, installation and commissioning. This report provides the basis for the technical baseline of the NOνA Project.

Meetings and Reviews

Various meetings between the Directorate, Project Management, Subproject Managers and the Collaboration will be held at appropriate intervals to ensure management of the overall project.

NOνA Project Management Group (PMG)

Meetings will be convened by the Associate Director for Research to monitor the progress of the project.

NOνA Technical Board

Frequent meetings between the Project Management and the Subproject Managers will take place throughout the life of the project. Full discussion of all issues related to the status of the Project – technical, schedule, cost, personnel issues and needs – are covered here on a regular basis. Also discussed are issues associated with risk, ES&H, quality management and value management.

General Project Meetings

General project meetings take place on a weekly basis and provide the opportunity for project participants at every level to present status reports, discuss current issues and disseminate news and information. These meetings are of general interest to anyone involved in the Project and serve to integrate diverse activities and provide an opportunity for physicists to criticize work in areas other than their own in this large project.

10 ACQUISITION STRATEGY

The acquisition strategy is detailed in the Acquisition Strategy for the NOνA Project. In the following sections we summarize this document.

10.1 Construction and Fabrication

Fabrication of components and subsystems will be done in-house using Fermilab facilities, by outside vendors working under subcontract to the Laboratory or NOνA collaborating institutions, and by NOνA collaborators at their home institutions. The responsibilities of each participating institution are further described in Memoranda of Understanding between the Project and the participating institution.

10.2 Procurement Plan

The components of the NOνA Project will be acquired in a manner consistent with DOE and general Fermilab guidelines. Whenever possible, fixed-price competitive procurement practices will be followed. The Fermilab procurements group will process purchase requisitions after appropriate approval or by delegation to procurement groups of participating institutions.

10.3 Inspection and Acceptance

The Project Manager will be responsible for assuring that the appropriate procedures are in place at the subproject level to ensure that components and assemblies are inspected sufficiently to assure satisfaction of technical specifications. The subproject manager is responsible for devising appropriate inspections. Acceptance of components and systems will be done by those individuals directly responsible for them. When appropriate, inspection visits will be made to vendor shops, collaborating institutions and industrial firms fabricating or preparing components for the project.

10.4 System Testing and Check out

Once components are assembled and integrated into a subsystem, 'system tests' will be performed. These tests will involve the activation, debugging and tune-up of the full subsystem. Though such tests pertain to the system under study alone, they may require other subsystems to be operational to enable the tests. Examples of system tests include readout of cosmic ray data from installed module planes after they have been filled with liquid scintillator. An integration prototype of the near detector will be constructed as part of the NOνA R&D effort and will be used for early system tests of prototype parts. As the project progresses the integration prototype can be upgraded with production parts for further system tests.

Check out consists of the process of integrating working subsystems into an operational experiment, and is the final stage of preparation for actual data taking. At this stage interactions and potential conflicts between distinct detector, trigger and readout systems are confronted for the first time. The check out process will evolve gradually, as subsystems are assembled and system tests performed. Lastly, full operation of the detectors begins.

10.5 Interdependencies and Interfaces

The land to be used for construction of the far detector hall will be provided and owned by the University of Minnesota and is not funded on project. Construction of the far detector hall is funded through the project, but the University of Minnesota, who will ultimately be responsible for ES&H and safeguards and security, will own the building. The University of Minnesota is considered a distinct entity from the University of Minnesota HEP group that collaborates on NOνA. This is similar to the execution of the MINOS project where Fermilab did not own the Soudan mine or the MINOS detector cavern. Fermilab, the NOνA Project and the University of Minnesota will be required to work closely with one another to ensure that the project is successfully executed in a safe and efficient way. The responsibilities of the various parties and the mechanisms that govern their interactions will be clearly defined in one or more MOUs. A draft MOU is being prepared using MINOS as a model. In the MINOS model, a Fermilab ES&H committee advised the University of Minnesota on ES&H issues as if the detector were located on the Fermilab site. The input was used by the University in their safety reviews as the responsible party.

11 TECHNICAL CONSIDERATIONS

Technical considerations are presented and examined in detail as part of the Conceptual and Technical Design Reports for NOνA. A brief summary of the research and development considerations are presented here.

NOνA began by defining a high level set of requirements needed to achieve its mission goals. R&D was undertaken on accelerator and NuMI components as well as detector technologies that were plausible candidates to meet the requirements. After the R&D was completed, the best technology in each area was chosen for the baseline. Considerations that entered into the choice included, but were not limited to, technical performance, construction cost, impact on the schedule, degree of risk, ability to successfully integrate and operate with the rest of the detector, robustness of operation, lifetime cost including operation, maintenance and removal, and the capability and experience of the project team with the technology. In some cases, when two choices appeared to be very close, we chose one as the baseline but continued R&D on the other as an "option." This creates competition that should result in lower costs and is an important component of the value engineering process discussed below.

The R&D included simulation, prototyping, bench-testing, and testing with cosmic rays. Development work on NOνA was, in many cases, similar to work going on elsewhere in High Energy Physics. An effort was made to benefit from the work of other groups. Wherever possible, NOνA used commercial solutions rather than in-house designed approaches. As a result, there is a complete and stable baseline, with only a few options, and many of the subsystems are well along into their design phase. R&D will continue in FY07 and will finish in FY10. In all cases, this R&D is directed towards optimization of the design and reducing the overall cost.

Research and development is performed on accelerator, NuMI and detector components to ensure that the chosen technology will meet the physics and engineering requirements. Designs are documented in design reports and drawings are checked by peers, senior engineers and/or managers. Design reviews are performed. Design reports, specifications, drawings and other documentation not located at FNAL will

be delivered to FNAL to ensure that detector components can be supported and maintained.

12 QUALITY ASSURANCE PROGRAM

Quality Assurance is an integral part of the design, fabrication, construction and installation of the NOνA Project. Special attention is paid to items that are most critical to the schedule and performance requirements of the Project. All work performed at Fermilab will draw on the guidelines and criteria set out in the Fermilab Director's Policy Manual, section 10. These include:

- management criteria related to organizational structure, responsibilities, planning, scheduling, and cost control;
- training and qualifications of personnel;
- quality improvement;
- documentation and records;
- work processes;
- engineering and design;
- procurement;
- inspection and acceptance testing;
- assessment.

Quality Assurance and Quality Control (QA/QC) systems are designed, as part of the Quality Management Program (NOvA-doc-1353), to ensure that the components of the accelerator, NuMI and detector meet the design specifications and operate within the parameters mandated by the requirements of the High Energy Physics Program. The QA/QC elements currently in place for the NOνA Project draw heavily on the experience gained from past detector construction and accelerator projects. Senior management recognizes prompt identification and documentation of deficiencies, coupled with the identification and correction of the root causes, are key aspects of any effective QA/QC Program. The Project Manager endorses and promotes an environment in which all personnel are expected to identify nonconforming items or activities and potential areas for improvement.

Accelerator, beamline and Detector components are fabricated specifically for NOνA by either commercial vendors, other Department of Energy Laboratories, member universities within the NOνA Collaboration, Fermilab owned facilities, or some combination of the above. The items manufactured may be individual components, detector sub-assemblies, or a complete piece of equipment being installed as part of the Project. It is the responsibility of the Project Manager and/or Project Leaders to have adequate verification methods in place to assure that only properly trained, qualified, and certified personnel are involved in the design, manufacture, and installation of detector components.

All components must be fabricated to pre-determined design specifications that will allow them to operate properly when integrated into the total system. Agreements will be in place with each vendor that explicitly states the operating parameters of the piece or pieces they construct. These agreements will also assign the responsibilities for testing and verification of the final product. Procured items must meet established requirements and perform as specified. In some cases, random testing of a certain percentage of components will be performed and documented by an independent organization. In the event that non-conforming items are discovered, they will be documented and controlled to preclude inappropriate use until compliance with the applicable technical requirements is demonstrated. Vendor

qualifications are reviewed as part of the bid process and are taken into consideration prior to bids being awarded. Vendor site visits may be conducted periodically throughout the duration of the fabrication contracts to ensure quality requirements are understood and being adhered to properly. Every electronic system should have as an essential part of its deliverable a fully documented testing and trouble shooting procedure.

Within NOνA production facilities, a Traveler will accompany each component through the assembly process. These information packets are used to identify, report, correct, and trend non-conformance situations adverse to quality detector performance. The Travelers will contain whatever historical information accompanies the equipment, list the specified operating parameters, and provide a place for testing results to be entered. The test results and certifications will then be compared to the required specifications and a determination will be made as to the final use or disposition of the item. It should be noted that testing and verification for performance within proper operating parameters will occur multiple times throughout the construction process as was the case during past detector construction projects. This multi-tiered testing approach will ensure that improperly installed, faulty, or failed components are detected at the earliest possible opportunity and allow immediate remedial action to be taken without jeopardizing or negatively impacting detector operation.

13 VALUE MANAGEMENT

Value Management (VM) is a process by which costs can be reduced through an analysis of a product's function, without sacrificing its performance and quality. The focus on a reduced cost, enhanced value relationship, determined through a functional analysis is integral to the design process for large scientific projects. The process itself is done in a different fashion than is generally employed in an industrial or construction setting. The NOνA Project and Fermilab are committed to VM principles in the design, d construction and installation of the accelerator upgrades, beamline components, experiment and associated infrastructure. VM is accomplished in the NOνA Project through an extensive design review process which each subproject and component is subject to before beginning construction. This peer review process takes place in external reviews conducted by Fermilab and the Department of Energy, and in internal reviews to determine baseline costs, technical adequacy, and production readiness. As discussed in Section 12, systems are designed, as part of the Quality Management Program, to ensure that the components of the accelerator, beamline and detector meet the design specifications and operate within the parameters mandated by the requirements of the High Energy Physics Program. Value Management in the NOνA Project is part of that process.

14 CONFIGURATION MANAGEMENT

Configuration management refers to the techniques used to version and tag the components of the project in order to identify and track the configuration at all times throughout its construction and its operational lifetime. The NOνA Project uses several tools to achieve this objective. These include a document control system that supports versioning and document signoff to "approve" a version; drawing management systems; and software control and a versioning and release system based on a software repository.

The NOνA Configuration Management Plan, NOνA-doc-131, is under document control and can be found at here.

15 ENGINEERING DESIGN REVIEW

Engineering design review is part of the NOνA Quality Assurance Plan (NOνA-doc-1353) and is a constant and ongoing process to ensure that all aspects of NOνA are engineered and designed to appropriate standards, satisfy ES&H requirements, are cost effective and meet the technical requirements.

Engineering and design is initiated by Level 2 managers and executed by engineers and designers working closely with members of the NOνA Project team. The process begins with the development of requirements documents that serve as input to the engineering and design process. Level 2 managers routinely hold internal design reviews and the engineering and design process is routinely monitored by the Project Engineers and presented to Project Management at Technical Board and Collaboration meetings. Particularly challenging engineering and design tasks are monitored closely by the Project Manager who organizes occasional internal reviews. In some critical cases, the Project Manager will organize a task force to meet regularly until difficult engineering and design issues are better understood and under control. Technical issues that pose moderate or severe risk to the Project are documented as part of the NOνA Risk Management program. Mitigation strategies, including potential work-arounds and fallback plans are developed. Moderate and severe risks are documented and monitored by the NOνA Risk Management Board until the risk is mitigated.

During the engineering and design process drawings and documents are under configuration management control as described in NOνA's Configuration Management Plan (NOνA-doc-131). Once designs are final they are managed according to NOνA's change control procedures described in Chapter 7.

16 INTEGRATED SAFETY MANAGEMENT

This section describes the policies for ensuring that Environmental, Safety and Health (ES&H) considerations are adequately addressed within the NOνA Project activities. The information below provides an overview of key issues. ES&H is a line management responsibility and will be implemented down through the sub-system organizations.

16.1 Overview

Fermilab subscribes to the philosophy of Integrated Safety Management (ISM) for all work conducted on the Fermilab site and requires its subcontractors and sub-tier contractors to do the same. Integrated Safety Management is a system for performing work safely and in an environmentally responsible manner. The term "integrated" is used to indicate that the ES&H management systems are normal and natural elements of doing work. The intent is to integrate the management of ES&H with the

management of the other primary elements of work: quality, cost, and schedule. The seven principles of ISM are as follows:

1) Line Management Responsibility for Safety: Line management is responsible and accountable for the protection of the employees, the public and the environment.

2) Clear Roles and Responsibilities: The roles and responsibilities, and authority at all levels of the organization, including potential sub-tier contractors are clearly identified.

3) Competence Commensurate with Responsibility: Personnel possess the experience, knowledge, skills and abilities that are necessary to discharge their responsibilities.

4) Balanced Priorities: Resources are effectively allocated to address safety, programmatic and operational considerations. Protecting the public, the workers and the environment shall be a priority whenever activities are planned and performed.

5) Identification of Safety Standards and Requirements: Before work is performed, the associated hazards are evaluated and an agreed upon set of safety standards and requirements are established which will provide adequate assurance that the public, the workers and the environment are protected from adverse consequences.

6) Hazard Controls Tailored to Work Being Performed: Administrative and engineering controls, tailored to the work being performed, are present to prevent and mitigate hazards.

7) Operations Authorization: The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and understood by all.

The NOνA ES&H program is intended to ensure that all relevant and necessary actions are taken to provide a safe working environment for the design, construction, installation, test and operation of the NOνA detector.

16.2 Objectives

The following general objectives have been established by FNAL for the ES&H program for the NOνA Project:

- Establish and administer an ES&H program that promotes the accomplishment of FNAL ES&H objectives for employees and non-employees.
- Protect the general public and the environment from harm.
- Comply with federal, state and local laws, rules and regulations.
- Prevent personnel injury or loss of life during project related work.

- Prevent damage to equipment caused by accidents during-project -related work.
- Prevent any environmental contamination during accelerator and detector development, fabrication, commissioning and operation.

16.3 Organization and Responsibilities

The overall ES&H program for the NOνA Project is the responsibility of the NOνA PM. The NOνA PM and his designees are responsible for establishing policies and requirements for ES&H during development and commissioning of the accelerator, detector, and related experimental systems. The NOνA PM has the responsibility for identifying specific ES&H issues and risks, and for ensuring that appropriate safeguards and procedures for addressing those risks for each subproject are implemented.

Activities conducted at universities will adhere to the ES&H policies and procedures of those specific institutions. The annual Statements of Work (SOW) signed between the institution and the NOνA project will identify a responsible safety person for NOνA activities at each institution.

16.4 Documentation and Training

The NOνA PM is responsible for providing, as required, specific requirements and procedures, as well as hazard assessments, and other documents to comply with DOE and FNAL requirements. Those who are on the NOνA project at the FNAL site will be provided with the training and information necessary to reduce the risks associated with their work and to ensure their safety. Briefings and presentations will be made to all managers and supervisors to communicate ES&H policies, documentation and information associated with assuring safety of NOνA activities. Job specific training will be provided on issues including electrical safety, radiation safety and chemical safety, as well as issues related to detector transportation, installation and testing activities. Proficiency testing is performed to gauge comprehension.

Appendix A: List of Referenced Documents

NOνA Proposal

Letter of Approval from the Fermilab Director

NOνA Conceptual Design Report

Proton Plan 2 Conceptual Design Report

NOνA Memoranda of Understanding and Work plans for each sub-project

Justification of Mission Need

Fermilab Project Control Systems Guidelines, May 1, 1994.

Acquisition Strategy for the NOνA Project at Fermi National Accelerator Laboratory

DOE Project Execution Plan for the NOνA Project at Fermi National Accelerator Laboratory

Fermilab Environment, Safety, & Health Manual (FESHM)

NOνA Quality Management Program